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IN THE

SUPREME COURT OF THE UNITED STATES

October Term, 1997

KUMHO TIRE COMPANY, LTD., *et al.*

Petitioners,

v.

PATRICK CARMICHAEL, *et al.*,

Respondents.

ON WRIT OF CERTIORARI TO THE
UNITED STATES COURT OF APPEALS
FOR THE ELEVENTH CIRCUIT

BRIEF *AMICUS CURIAE* OF STEPHEN N. BOBO, DONALD G. CARTER, WILLIAM J. COAD, ERNEST L. DAMAN, JOHN D. GRAHAM, NATHAN H. HURT, A. ALAN MOGHISSI, FRANCESCO POMPEI, JAMES R. WALLACE AND RICHARD WILSON IN SUPPORT OF PETITIONER

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INTRODUCTORY STATEMENT

This brief is submitted in support of the petitioners.[1,2]

Amici are individuals who are engineers and scientists. They have substantial experience in engineering and applied and basic science. They believe strongly that decisions involving scientific, technical, or other specialized knowledge, including judicial decisions allocating responsibility for injury, must be based on the best and most reliable information. When the information upon which those decisions are made purports to be based on scientific, technical or other specialized expertise, it is vital that the finders of fact not be exposed to testimony that is not based on appropriate and acceptable methodology and thus may be misleading.

INTEREST OF *AMICI*

As noted above, *amici* are scientists and engineers, active in their respective professions. Two of them are past presidents of the American Society of Mechanical Engineers (ASME), two are officers of the American Society of Heating, Refrigerating and Air Conditioning Engineers, one is currently chair of the Environmental Engineering Division of ASME. Others are active professional engineers. Some of them hold doctorates in "basic" science, "applied science" or engineering. All of them currently teach or formerly taught engineering or science. Three of them are on the faculty of Harvard University.

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[1] Letters from all parties consenting to the filing of this brief have been filed with the Clerk of this Court.

[2] Pursuant to Supreme Court Rule 37.6, *amici curiae* state that this brief was not prepared, written, funded or produced by any person or entity other than *amici curiae* or their counsel.

Stephen N. Bobo is a mechanical engineer with an international reputation in tire technology, particularly aircraft tires, and the application of nondestructive inspection to a diversity of industrial problems. He holds numerous patents in the field of nondestructive inspection and has written over a hundred papers in that field, advancing tire technology. He is President of Nondestructive Engineering, a consulting organization devoted to application of nondestructive inspection in industry. Under FAA sponsorship, he assisted in development of tire testing and retreading standards, and nondestructive inspection technology guidance for the nation's aircraft fleet. He assisted in development of nondestructive inspection qualification and certification standards for the FAA and wrote FAA documents entitled *Nondestructive Inspection for Aircraft* (1996); *Visual Inspection for Aircraft* (1994); and *Aircraft Propeller Maintenance and Inspection* (1997). Under sponsorship of Sandia National Laboratories he was a consultant on creation and introduction of a new version of the FAA's primary documents covering oversight of aircraft tires: TSO C62, *Aircraft Tires*, AC 145-4 *Inspection, Retread, Repair, and Alterations of Aircraft Tires*, and AC 20-97 *Aircraft Tire Maintenance and Operational Practices*. He consulted for the US Air Force Landing Gear Dynamics Laboratory, USAF Wright Laboratory on Aircraft Tire Retreading. He recently completed a summary report entitled *Nondestructive Inspection of Tires*, a survey of nondestructive inspection in the tire industry. He has conducted failure analysis on all major air carrier incidents involving tires and U.S. aircraft since 1978 as well as several foreign incidents. As a staff consulting engineer in tire technology and nondestructive inspection for the U.S. Department of Transportation, Mr. Bobo co-authored a survey on the availability of tires in the event of a military mobilization for the U.S. Army. He is the author of a U.S. Government monograph *Mechanics of Pneumatic Tires*. He has developed two advanced ultrasonic inspection systems, one of which has been used by a major retread equipment manufacturer for use in truck tire retreading. Mr. Bobo conducted failure analysis on the Firestone 500 which served in part as the basis for its

recall. He has carried out failure analysis on all major air carrier incidents involving tires and U.S. aircraft since 1978 as well as several foreign incidents. He received the Department of Transportation's Bronze Medal for "his contribution to the improvement of inspection and monitoring procedures for aircraft tires." Upon retirement he received a Secretary's citation for his "Global contribution to tire safety and thanks for the national standardization achieved in tire design." Mr. Bobo graduated U.S. Naval Academy in 1951. He is a member of the Society of Automotive Engineers.

Donald E. Carter is a registered professional engineer in the District of Columbia, Indiana, Maryland, North Carolina, Ohio, Pennsylvania, and Virginia. He is Vice-Chair of the District Columbia chapter of the American Society of Plumbing Engineers, past President of the Consulting Engineers Council of Washington, D.C., past President of the District of Columbia Council of the Engineering and Architectural Societies, National Chairman of the Construction Liaison Committee of the American Consulting Engineers Council, past Chairman of the Mechanical and Electrical Section of the Metropolitan Washington (D.C.) Consulting Engineers Council, and past Vice Chairman of the Consultative Council of the National Institute of Building Sciences. He is also a member of the Interprofessional Committee of the American Consulting Engineers Council and the Committee on Advanced Maintenance Concepts of the National Research Council of the National Academy of Sciences. He was on the editorial board of American Energy Week and on the board of advisors of Plumbing Engineer. Mr. Carter has been on the faculty or lectured at the University of the District of Columbia, the University of Tennessee, Texas A&M University, the University of Maryland, Catholic University and Howard University. He has received numerous awards in the field of engineering.

William J. Coad is Chairman of the Board of The McClure Corporation. He is a Vice President of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). He received his degree in Mechanical Engineering from Washington University in 1957. He has as a mechanical/electrical consulting engineer for the past 35 years, prior to which he worked as a design engineer, estimator and corporate officer of a mechanical contracting company. He is a registered professional engineer in 37 states. He has served as a lecturer in Mechanical Engineering for 12 years at Washington University in St. Louis, and, for 17 years as an Affiliate Professor teaching graduate courses in Mechanical Engineering and serving as a student thesis advisor in building environmental systems design. Mr. Coad is a member of the Consulting Engineer's Council, the American Society of Mechanical Engineers (ASME) and a Fellow in the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). He is a Vice President of ASHRAE. He received numerous awards from professional societies, including an award for the best paper published by ASHRAE in 1985, the Louise & Bill Holladay Distinguished Fellow Award in 1989 and ASHRAE's highest award for technical achievement in 1996. Mr. Coad is an Honorary Member of Pi Tau Sigma (Mechanical Engineering Honorary Society). He has published numerous articles in United States and foreign journals. He has written ENERGY ENGINEERING AND MANAGEMENT FOR BUILDING SYSTEMS and he is a co-author of PRINCIPLES OF HEATING, VENTILATING, AND AIR CONDITIONING" published by ASHRAE. He is a member of the Board of Editors of Heating/Piping/Air Conditioning Magazine.

Ernest L. Daman is Chairman Emeritus of Foster Wheeler Development Corporation and he previously served as Chairman of the Board of Foster Wheeler Development Corporation and before that as Director of Research of that company. He also held the position of Senior Vice President at its parent company, FWC. He is a Past President of

American Society of Mechanical Engineers. Mr. Daman was elected to the National Academy of Engineering. He is a member of the American Association for the Advancement of Science and Past Chairman of the American Association of Engineering Societies. He is a Fellow of the Institute of Energy (England). He served on several ASME committees as member or chairman. Ernest Daman is the author of numerous papers, and holds 18 patents. He was responsible for the design and development of a combined steam gas turbine plant, fluidized bed combustion, fast breeder reactor components, supercritical steam generators, environmental control processes, and advanced high-efficiency power generation systems. He received his B.M.E. from the Polytechnic Institute of Brooklyn.

John D. Graham is Director of the Center for Risk Analysis of the Harvard University School of Public Health and Professor of Public Policy and Decision Sciences in the Department of Health Policy and Management at the Harvard University School of Public Health. He was previously Director of the Center for Injury Control at the Harvard University School of Public Health. Professor Graham's doctoral dissertation was on "Automobile Safety: An Investigation of Occupant-Protection Policies." He is the author or editor of two books on automobile safety, and the author or co-author of over 100 published articles and papers, including numerous articles on automobile safety and crash protection, and automobile safety regulation and policy. He has been a member of the Highway Safety Study of the Strategic Transportation Research Committee of the Transportation Research Board of the National Research Council. He was a member of the NHSTA Motor Vehicle Safety Research Advisory Committee of the U.S. Department of Transportation. In 1991 he was elected president of the Society for Risk Analysis.

Nathan R. Hurt is vice president of IDM Environmental Corp. Previously, he worked for Los Alamos Technical Associates and the Goodyear Tire and Rubber

Company. He was president of the Goodyear Atomic Corporation, a subsidiary of Goodyear Tire. He is a mechanical engineer with 50 years of experience in the chemical and nuclear industries. Nathan Hurt is a recent Past President of the American Society of Mechanical Engineers. His chemical industry experience includes design, construction and plant management -- primarily in vinyl monomers and copolymers, synthetic rubbers and resins, and polyesters. His nuclear industry experience consists of project management, facilities management, and marketing in uranium enrichment and weapons plants. He is currently a member of the Nuclear Engineering Advisory Board of Worcester Polytechnic Institute. He received his B.S. in Mechanical Engineering from the University of Colorado and he is a registered professional engineer in Ohio.

A. Alan Moghissi is President of the Institute for Regulatory Science (RSI), a non-profit organization dedicated to the idea that societal decisions must be based on the best available scientific information. The activities of the Institute include research, scientific assessment, and science education at all levels-particularly the education of minorities. Dr. Moghissi held positions at the U.S. Public Health Service and, upon its formation, the U.S. Environmental Protection Agency (EPA). He served in a number of capacities at EPA, including Director of the Bioenvironmental/Radiological Research Division; Principal Science Advisor for Radiation and Hazardous Materials; and Manager of the Health and Environmental Risk Analysis Program. After his retirement from the EPA, Dr. Moghissi joined the University of Maryland at Baltimore as Assistant Vice President for Environmental Health and Safety; subsequently he was Associate Vice President for Environmental Health and Safety at Temple University in Philadelphia, Pennsylvania. He has been a visiting professor at Georgia Tech and at the University of Virginia. Dr. Moghissi's research has dealt with diverse subjects, ranging from measurement of pollutants to the biological effects of environmental agents. A major segment of

his research has been on scientific information upon which laws, regulations, and judicial decisions are based -- notably risk assessment. He has published over 300 papers and several books. He is the editor-in-chief of *Environment International* and of *Technology: Journal of The Franklin Institute*, which is one of America's oldest continuously published journals of science and technology. Dr. Moghissi is a member of the editorial board of several other scientific journals. He is chairman of the Environmental Division of the American Society of Mechanical Engineers. Dr. Moghissi received his education at the University of Zurich, in Switzerland, and Technical University of Karlsruhe in Germany, from which he received a doctorate in physical chemistry.

Francesco Pompei is President of Exergen Corporation, an engineering firm that designs, develops and manufactures infrared scanners, instrumentation and control devices for industrial and medical use. He holds undergraduate and graduate degrees in mechanical engineering from M.I.T. He is a doctoral candidate in the doctoral program in engineering sciences at Harvard University. He is the holder of over 30 United States patents for radiation detection, temperature measurement, fuel injection systems and heating technology. He is the author or co-author of over 20 articles published in peer reviewed journals, including the *New England Journal of Medicine*, *Medical Electronics*, and *Transactions* of ASHRAE.

James R. Wallace is a Senior Vice President and Director of Engineering and Science of Law Engineering and Environmental Services, Inc. He was professor of engineering at Georgia Institute of Technology from 1966 to 1978, where he was a professor of civil engineering. He holds a Doctor of Science degree in civil engineering from the Massachusetts Institute of Technology, and Master of Science and Bachelors of Science degrees in Civil Engineering from the Georgia Institute of Technology. He is a member of the American

Society of Civil Engineers, the American Geophysical Union, the American Institute of Hydrology and other professional organizations. He is a registered civil engineer in Georgia and Florida.

Richard Wilson is Mallinckrodt Professor of Physics and former Chairman of the Department of Physics at Harvard University. He is a member of numerous committees and is consultant to numerous government and academic institutions including the Physics Advisory Board of the National Science Foundation, a member of the Breeder Reactor Safety Committee of the Energy Research and Development Administration, a consultant to the Los Alamos, Oak Ridge and Lawrence Livermore laboratories, chairman of the Visiting Committee on Radiation Medicine, Massachusetts General Hospital and Director of the Sakharov Foundation. He is a fellow or member of the American Physical Society, the American Academy of Arts and Sciences and the Society for Psychical Research (London).

Amici are scientists and engineers who have studied the issue of the role that scientific and engineering issues play in public affairs and in particular the way in which they can illuminate disputes between different persons or elements of society in the courts of law. Some of the *amici* submitted a brief in the Supreme Court in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993) (hereafter "*Daubert*"), the seminal case discussing the rule for admissibility of expert scientific evidence. *Amici* support the principles enunciated by the Supreme Court in that case, and believe that those principles should have wide applicability at the interface between science and law and policy.

Amici firmly believe that the United States Court of Appeals for the Eleventh Circuit incorrectly held, in substance, that testimony as to the alleged failure of a technologically produced object is not "scientific" and is not subject to the Federal Rule of Evidence 702 and the *Daubert* standards.

Amici also believe that the principles that govern the study of reliability and failure of technical objects, systems and components should, can, and to a considerable extent do, follow identical or substantially similar scientific principles as any application of these same principles to "basic" sciences such as astronomy, physics and chemistry. Indeed, this is already recognized by this Court in *Daubert*, which was not a discussion of the principles that apply exclusively to a basic science but comprehended issues of causation in which technical knowledge is used to explain observed phenomena.

The decision of the District Court to exclude testimony of plaintiffs' expert was well within the scope of the guidelines enunciated by this Court in *Daubert* and further endorsed and explained in *General Electric Co. v. Joiner*, ___ U.S. ___, 118 S.Ct. 512, 139 L.Ed.2d 508 (1997) (hereafter "*Joiner*").

STATEMENT OF THE CASE

Plaintiffs-Respondents in this case are eight members of the Carmichael family who were involved in a severe automobile mishap when the rear right tire on their minivan failed. That the tire failed and that this caused the accident which in turn caused significant trauma to each of the Carmichaels is not in dispute. The claim by the plaintiffs is that the failure was caused by a manufacturing defect.

To establish that the tire failure was caused by a manufacturing defect, plaintiffs proffered the testimony of one witness, Mr. Dennis Carlson, an engineer employed as a tire consultant. The district court excluded Mr. Carlson's proffered testimony about causation under Fed. R. Evid. 702 and 403. Since no other evidence was offered by plaintiffs on the issue of causation, the trial court granted defendants' motion for summary judgement. Plaintiffs appealed, and the Court of Appeals for the Eleventh Circuit reversed and remanded, holding that the district court erred in applying the *Daubert* criteria to the proffered testimony of Mr. Carlson. According to the Court of Appeals, *Daubert* standards apply only to

"scientific" and not to "non-scientific" evidence and the judgment of tire failure, which the Circuit Court held to be non-scientific. *Carmichael v. Samyang Tire, Inc.*, 131 F.3d 1453 (11th Cir. 1997).

Carlson, the sole expert witness for the plaintiffs testified that the tire had been driven for many thousands of miles, that the tread depth was down to zero inches in places, down from 10/32 of an inch when new. Carlson conceded that the separation most likely began under a bald spot on the tire, where the tread was completely worn. Transcript of deposition of Dennis Carlson (hereafter "Carlson Tr.") at 488. The tire had been punctured by a nail or screw during some point in its life and the plaintiff's witness testified that the exterior holes caused by the puncture had not been adequately repaired. *See Carmichael v. Samyang Tires, Inc.*, 923 F. Supp. 1514, 1517 (S.D. Ala. 1996)

SUMMARY OF ARGUMENT

The Court of Appeals incorrectly states that *Daubert*, which has been elaborated upon by this Court in *Joiner*, is inapplicable to this case. The decision of the Eleventh Circuit is based on a fundamental mischaracterization of *Daubert* and a flawed perception of engineering, in particular the field of safety and reliability engineering.

Daubert itself, and *Joiner* which followed, applied the "Daubert factors" to the assessment of causation of disease in medical science. The Supreme Court did not suggested that those principles or the scientific method itself are limited to medical science, basic science, or any other science. Indeed, those cases emphasized that Rule 702 and the trial court's responsibility for ensuring that expert testimony that purports to be based on "scientific, technical *or other specialized knowledge"* is reliable.

Analysis of device, component and system failure and of safety generally are resolved in engineering using the methodology outlined in *Daubert*: formulating an hypothesis, testing the hypothesis, subjecting the hypothesis to review and testing by others, often but not always through publication and peer review, and, if appropriate, refinement of the hypothesis.

ARGUMENT

I. *Daubert* Applies Not Only to Testimony Grounded in "Basic" Science, But to All Testimony Based on Scientific, Technical or Other Specialized Knowledge

In this case, the United States District Court for the Southern District of Alabama (reported at 923 F. Supp. 1514) excluded the testimony of plaintiffs' "tire failure expert" because it deemed that testimony (given on deposition) to be unreliable under the standards established in *Daubert*. The Court of Appeals for the Eleventh Circuit reversed, holding that *Daubert* applies only to testimony of a "an expert who relies on the application of scientific principles, rather than on skill- or experience-based observation" as the basis of his opinion. *Carmichael v. Samyang Tire, Inc.*, 131 F.3d 1433, 1435 (11th Cir. 1997).

The rational of the Court of Appeals is, we submit, a misreading of *Daubert* and Rule 702. It creates an exception to Rule 702 and *Daubert* that "swallows the rule." It also results in a serious paradox and an anomaly that is impractical and unworkable.

In *Daubert v. Merrell Dow Pharmaceuticals*, 509 U.S. 579, 113 S.Ct. 2786, 125 L.Ed. 2d 469 (1993) (hereafter *"Daubert"*), this Court concluded that Rule 702 of the Federal Rules of Evidence provided the framework for the proper test for admissibility of scientific and technical evidence.

Under the Federal Rules of Evidence, the trial judge must ensure that any and all scientific, technical or other specialized testimony or evidence admitted is not only relevant, but reliable.

> The primary locus of this obligation is Rule 702, which clearly contemplates some degree of regulation of the subjects and theories about which an expert may testify. *If scientific, technical, or other specialized knowledge will assist the trier of fact* to understand the evidence or to determine a fact in issue an expert "may testify thereto."

Daubert, 509 U.S. at 589-90, 113 S. Ct. at 2794-95 (emphasis in original) (internal citations and footnotes omitted).

Rule 702 applies to "scientific, technical and other specialized knowledge." In clarifying the language of Rule 702, the Court in *Daubert* emphasized the word "knowledge," which "applies to *any* body of known facts or to *any* body of ideas inferred from such facts or accepted as truths on good grounds." *Id.* at 590. (quoting Webster's Third New International Dictionary of the English Language Unabridged (1971) at 1252) (emphasis added).

In *Daubert*, 509 U.S. at 593-95 this Court described five non-exclusive factor, flexible test for district courts to consider when assessing whether the methodology is scientifically valid or reliable. These factors include:

(1) whether the expert's theory can be or has been tested;

(2) whether the theory has been subject to peer review and publication;

(3) the known or potential rate of error of a technique or theory when applied;

(4) the existence and maintenance of standards and controls; and

(5) the degree to which the technique or theory has been generally accepted in the scientific community.

The major lesson of *Daubert* is that the district courts must act as "gatekeepers" to ensure the "reliability" of expert testimony submitted to the jury. 505 U.S., fn. 9 at 591. Rule 702's "knowledge" requirement "connotes more than subjective belief or unsupported speculation." 505 U.S. at 591.

The criteria enumerated in *Daubert* were merely hallmarks of "good science." When dealing with the field of engineering or other technical disciplines, one or more of the *Daubert* criteria may not be appropriate, but some of the *Daubert* tests and perhaps other criteria should be applied.[3] For example, in engineering "publication" and "peer review" may not be customary with respect to product design or manufacturing processes, which are often proprietary. But testing is often an integral part of the design engineering process.

The real question, therefore, is not whether *Daubert* applies to expert testimony that does not relate to "science" narrowly defined, but how to assure that all experts testify based on valid and reliable knowledge from whatever field might be pertinent.

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[3] The Court itself stated that it did not intend to "presume to set out a definitive checklist or test" and instead described the criteria as "general observations." 505 U.S. at 594, 113 S. Ct. at 2796.

It is most unlikely that a "scientific" issue that reaches the courts will be one of theoretical science. Because legal disputes arise in the everyday interactions of society, the "science" issues that bear on legal adjudication will always or almost always involve the application of scientific principles to practical questions.

In cases involving the application of science to a concrete and practical problem, such as to those involving engineering principles, some of the factors articulated in *Daubert* might not apply or might be less important, but given the importance of testing in the design process -- a point which plaintiff's expert conceded -- his failure to test the failed tire or to test similar tires produced using the same design and manufacturing process rendered his testimony unreliable.

The goal should be to ensure that experts adhere to the same standards of intellectual and methodological rigor that are demanded in their professional work.

In many technical but not "pure" scientific professions, processes analogous, but not identical, to the scientific method have been developed. The methodologies of these professions are often influenced by the methodologies of science and provide objective criteria for ascertaining evidentiary reliability of expert testimony proffered in these fields.

The underlying reason for Rule 702 is to ensure that the expert testimony offered in court has been derived by the same methodology and intellectual rigor demanded of experts in the same field in their professional work. Professionals in many non-scientific fields have developed standards and methodologies for their work; the court can ensure the validity of the expert's methodology under Rule 702 by reference to those standards. In fields of expertise in which technical standards or methodologies already exist, a starting point is to determine whether the expert has followed the recognized methodology or standards of that professional field.

Engineering and similar fields of applied science are prime examples of technical expertise in which the methodology of science plays a central role. "Engineering" is defined by WEBSTER'S NEW COLLEGIATE DICTIONARY (1980) as "the application of science or mathematics by which the properties of matter and sources of energy in nature are made useful to man in structure, machines, products, systems, and processes."

Engineering predates modern science, but it has always relied on experimentation and inventiveness, along with practical knowledge and common sense. There is much overlap between the fields of science and engineering, and present day engineers use science extensively. In many ways engineering is simply applied science. Other fields in which expert witnesses often testify, such as accident reconstruction, metallurgy, and fire investigation, also depend upon principles of science. The characteristics of a piece of a given material are measurable, testable and thus predictable if one knows the external environment in which the material is to be used.

Although there are some differences between scientific and technical knowledge, in a case where the expert opinions could be substantiated by scientific or similar methodology the factors expressed in *Daubert* are relevant and useful for measuring the reliability of the expert's testimony.

The goal, articulated in Rule 702 and in *Daubert*, should be to assure that the techniques and methodologies used by experts in the particular field in rendering an opinion for court testimony are the same as those that an expert in the field would use in reaching a professional opinion outside the courtroom. Whatever the source of standards, Rule 702 requires that a witness' testimony reflect the methods and practices of the field of expertise at issue.

Under the Eleventh Circuit's analysis, an expert who attempts to apply the rigors of a scientific analysis to his inquiry is subject to more stringent review than one in the same

field who ignores logic, rigorous methodology and close examination and instead relies on intuition and experience that cannot be tested objectively. This, we submit, turns Rule 702 on its head and creates an exception to *Daubert* that is big enough "to drive a Mack truck through."

As the Fifth Circuit observed in *Watkins v. Telsmith, Inc.*, 121 F.3d 984, 990 (5th Cir.1997)

> . . .[I]t seems exactly backwards that experts who purport to rely on general engineering principles and practical experience might escape screening by the district court simply by stating that their conclusions were not reached by any particular method or technique. The moral of this approach would be, the less factual support for an expert's opinion, the better.

II. THE DISCIPLINE OF FAILURE ANALYSIS IS FOUNDED ON ENGINEERING PRINCIPLES WHICH ARE SIMILAR TO THOSE IN OTHER AREAS OF SCIENCE.

The decision of the Court of Appeals in this case is based on the proposition that the judgement of causation in tire failure is not a science, that its methodology is not that of science, and that consequently the evidentiary standards enunciated by the Supreme Court in *Daubert v Merrell Dow Pharmaceuticals* are not applicable. 126 F.3d 682.

The Court of Appeals' error lies in the assumption that the study of device safety and failure causation is not science and does not need to follow scientific principles. The decision disregards the existence of a well-established branch of engineering that predicts the occurrence of accidents and their consequences and evaluates accidents and assesses their causation.

The safety and reliability of a manufactured item is an integral part of the engineering design. Furthermore, engineers have developed methods to assess the quality of manufacturing process by various tests that are routinely performed at manufacturing plants.

Manufacture and testing of tires is an engineering process. Testing for tire failure at the manufacturing stage is in many respects similar to the testing performed for tires that have been subjected to wear and tear. In fact manufacturers rely heavily upon the evaluation of used tires in improving the quality of manufacturing process. There are numerous objective tests for evaluation of tire quality. The Appendix to this brief lists consensus tests developed by the American Association for Testing Materials that relate to testing of quality and properties of tires.

The core of the decision of the Court of Appeals is based on the erroneous assumption that a visual inspection by an experienced individual suffices to unambiguously identify faulty manufacturing.

The plaintiffs' expert claimed that he looks for four criteria in determining "whether a defect has caused the tire failure." "[He] looks for the following signs of overdeflection: (1) greater tread wear on the shoulder than in the center of the tire; (2) sidewall deterioration and discoloration (3) abnormal bead grooving on the tire and (4) rim flange impression. . . .When Carlson fails to find sufficient evidence of two of these four indicators in a tire, he rules out overdeflection as a cause of tire failure and, barring other evidence of abuse, concludes that the loss of adhesion was prompted by a manufacturing or design defect". *Carmichael v. Samyang Tires, Inc.*, 923 F.Supp. 1514, 1519 (S.D. Ala. 1996) (citing Carlson Tr. 250-252, 278-279, 390).

Carlson examined the tire in issue for the first time on the morning of his deposition. He performed no tests on the

tire that is accused of causing the accident, nor did he test any of the other tires on the vehicle at that time. Carlson Tr. 328. His analysis was limited to a visual inspection of the tire, although he agreed that sectioning the tire could reveal additional pertinent information. Carlson Tr. 381.

In his examination of the tire, Carlson observed some evidence of uneven tread wear, sidewall deterioration, abnormal bead grooving, and rim flange impressions; however, he found that the evidence with respect to each factor was either insufficient to demonstrate overdeflection or that it was attributable to causes other than overdeflection. Carlson Tr. 403-06, 445-46, 449-56. Based on this testimony, Carlson asserted that there was no evidence of overdeflection in the tire. Carlson Tr. 462.

After ruling out overdeflection and other forms of abuse, Carlson concluded that the tire failure must have been precipitated by a manufacturing or design defect in the tire. However, neither the plaintiffs' written submissions nor the Court's review of Carlson's voluminous deposition transcripts indicate that Carlson identified any affirmative evidence of a defect in the tire. Stated differently, Carlson's expert opinion that the tire failure was caused by a manufacturing or design defect is founded on his determination that there is a paucity of evidence of overdeflection or other abuse, rather than by his ability to pinpoint any affirmative evidence of a defect.

It must be borne in mind that Carlson is a mechanical engineer, and presumably his expertise derives from his educational credentials and his prior employment with a major tire manufacturer. Had been a carpenter or tailor who took up "tire failure analysis" as a vocation, he would not, we are certain, be permitted to testify. As an engineering professional, his testimony should be subjected to close scrutiny for adherence to professional standards.

Nowhere did Carlson provide any evidence that his criteria are proven to be those needed to be considered, nor does he provides any reason for his choice of accepting two of these criteria (as compared to one, three or all four of them) as sufficient to conclude that the tire failed because of a manufacturing defect. Even if one were to accept Carlson's four criteria and his belief that two out of four were dispositive, visual tests are subject to considerable interpretation.[4] For example, what Carlson may consider to be discoloration someone else may not. The engineering profession has instruments that not only detects variations in color, but also their magnitude or intensity.

The field of failure analysis is considerably more developed than an arbitrary selection of four criteria, accepting two out of four and relying upon visual inspection. During the tire manufacturing process a number of tests are performed to ensure tire quality. These include X-ray checks on tires for ply cord spacing and belt lay up and a host of other tests shown in the tables in the Addendum to this brief.

Carlson's method for analyzing the tire is not susceptible to independent testing or falsification. His method is entirely subjective. *See* Carlson Tr. 276-284, 402. Carlson described tests or other procedures that could be used to corroborate or refute the results of his visual inspection of the tire at issue, but he did not use any of them. Carlson Tr. 276-278; 295-296; 302; 387-388.[5] When asked if there were any

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[4] We emphasize that Carlson examined the failed tire only on the morning of his deposition. He relied upon, and adopted almost verbatim, the observations of his deceased colleague, without having participated in his colleagues observation or analysis of the tire.

[5] Although Carlson rationalized his failure to use these tests because they would be unreliable after a tire had failed (Carlson Tr. 295-296), he did not explain why he did not do such tests on the other

chemical tests that he could have conducted on the tire, Carlson responded, "I don't think there are any that would apply to this case." Carlson Tr. 388.

Carlson also conceded that there are no publications or papers which have described or discussed (let alone approved) his techniques for tire failure analysis. While he identified a number of publications and research papers describing tests which can be performed to assess the causes of abnormal tread wear and asserted that he relied on such papers in his testimony in this case, Carlson Tr. 285, he did not actually perform any of the tests described in this literature on the tire in question; he testified only that he "probably" relied on the information provided in those documents as "background" for the work that he did. Carlson Tr. 285, 287.

Carlson did not know whether his previous analyses of failed tires using the same methodology were correct or not. He did not test his methods in a controlled setting (and did not know if anyone else had) to gauge their accuracy in correctly distinguishing between overdeflected and defective tire separations. Carlson Tr. 285-287.

Carlson conceded that there are a number of publications and research papers regarding tests which can be performed to assess the causes of abnormal tread wear. Presumably he was referring to the ASTM[6] and ANSI tests that are commonly used in the tire industry. Carlson was also engaged in tire testing when he was employed by Michelin, a

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tires on the vehicle or tires from the same manufacturing lot as the one that failed to see if there were identifiable features of design or production technique that led to failure. Carlson did not even testify that other tires of the same type had a history of this kind of failure.

[6] A listing of relevant ASTM standards is provided in the Appendix to this brief.

major tire manufacturer. However, he did not describe or perform any objective test or measurement upon which relied to demonstrate the cause of tire failure in this case.

There is substantial technical literature on assessment of tire quality, tire safety and failure assessment. The engineering profession, notably automotive and mechanical engineers, have applied scientific processes for the life cycle of tires. This includes assessment of causes of tire failure. The engineering profession relies upon objective, verifiable and reproducible technical information. Peer review and consensus processes are as much the foundation of engineering as they are the foundation of science. Accordingly, *Daubert* applies to engineering as much as it applies to science.

The procedure adopted by Mr. Carlson (Carlson Tr. 303) seems superficially to follow a scientific method. For example, he seems to consider possible causes of tire failure and eliminate those which are not defects in manufacture. While he made a colorful statement (Carlson Tr. 392), "well, besides nuclear war that's about all there is that causes tire failure," he produced no publication, no statistical data, and only the reading of other depositions as a justification for his "proce[illegible]" or his conclusion (Carlson Tr. 303).

While, therefore, the Court of Appeals is correct in referring to Mr. Carlson's procedure as "unscientific," *amici* believe that a more scientific procedure was possible, and that admission of Mr. Carlson's proffered testimony to a jury, which might reasonably be expecting scientific testimony and which might accord Mr. Carlson's testimony the substantial weight usually accorded "scientific" testimony, would only cause confusion unless of course the jury were explicitly warned that the testimony would be unscientific.

III. Engineering science follows the same principles as other sciences.

The necessary attribute of any scientific theory, including a discussion of failure and accidents, is "falsifiability," that is whether it can be tested. This was emphasized by Sir Karl Popper, a philosopher of science quoted by the Supreme Court in *Daubert* (509 U.S. at 593).[7]

A scientist's or engineer's theory is useful only if it is falsifiable or testable. Even if one were to accept the idea (which the *amici* do not) that entirely different scientific principles apply to a study of safety of technological devices, systems and components (such as tires) than to other sciences, this would not apply to the study of causation of accidents or systems failure.

The object of a science may be said to be to construct theories about the behavior of whatever it is that the science studies. This aspect of science, the concoction of theories, has no universal method, but once a theory has evolved, perhaps from a half-baked idea to a precise and unambiguous statement, the scientific method may be used to judge the success or failure of a given theory or the relative merits of competing theories. Theories are known as hypotheses, and the process of judging them is called the testing of hypotheses.

A scientific hypothesis is tested by comparing its conclusions with the reality of the world as it is. Yet, no matter how many examples of agreement one may collect, they do not prove the truth of the hypothesis, for it may be

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[7] K. Popper, Conjectures and Refutations: The Growth of Scientific Knowledge 37 (5th ed. 1989) ("[The criterion of the scientific status of a theory is its falsifiability, or refutability, or testability").

argued that one has not tested it in the single case where the theory might fail to agree with reality. Just one instance of disagreement between the hypothesis and reality, if shown not to be the result of an error of experiment design, observation or measurement, is sufficient to make the hypothesis incontrovertibly false[8]. The current acceptance of an hypothesis is no assurance of its continued success.

Engineering shares certain characteristics with the positing of scientific theories, but instead of hypothesizing about the behavior of a given universe, whether of atoms, honeybees, or planets, engineers hypothesize about assemblages of concrete and steel that they arrange into a world of their own making. Each building, bridge or other structure or mechanical system may be considered to be a hypothesis in its own right. In particular, one hypothesis of a structural engineer might be that so and so bridge across such and such river under these and those conditions of traffic and maintenance will stand for so many years without collapsing. Now if such a bridge were built and were to carry traffic year after year without trouble, the hypothesis would be confirmed time and time

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[8] To use the example of bees favored by the Court of Appeals, that honeybees always build their hives with hexagonal cells is a hypothesis that has accumulated so much verification that it is hardly called a hypothesis anymore. It is assumed to be "fact." But if some apiarist discovers bees making octagonal cells, not only would the hypothesis that bees always use the hexagon be forever smashed, but there would also be quite a bit of excitement among the world of honeybee experts. That the sun rises each morning may also be considered a hypothesis, and our experience that indeed this happens day in and day out serves to confirm, but not prove, the hypothesis. All it would take would be a single "morning" without a sunrise to make the contention that the sun rises every morning categorically false. While it may be beyond our comprehension that this could ever be the case, it nevertheless remains true that our belief that the sun will rise tomorrow is basically a matter of faith rather than of rigorously established fact.

again, but it will never be *proven* until the so many years under the original plan had elapsed. But should the bridge collapse suddenly under no extraordinary conditions before those so many years were up, there would be no doubt that the hypothesis was incorrect.

As Henry Petroski, Chairman of the Department of Civil and Environmental Engineering at the School of Engineering at Duke University, has written:

> The process of engineering design may be considered a succession of hypotheses that such and such an arrangement of parts will perform a desired function *without fail*. As each hypothetical arrangement of parts is sketched either literally or figuratively on the calculation pad or computer screen, the candidate structure must be checked by analysis. The analysis consists of a series of questions about the behavior of the parts under the imagined conditions of use after construction. These questions may be easily answered for designs that are not particularly innovative, but a computer may be required to perform all the calculations needed to analyze a bold new design. If any of the parts fails the test of analysis, then the design itself may be said to be a failure. A design can be altered by strengthening the weak link and then analyzing the new design. The process continues until the designer can imagine no possible way in which the structure can fail under the anticipated use. Of course, if the designer makes an error in calculation or overlooks some possibility of failure or does not program the computer to ask the right question, then the hypothesis will erroneously be thought to have been verified when in fact it should have been disproved. Absolute certainty about the

> fail-proofness of a design can never be attained, for we can never be certain that we have been exhaustive in asking questions about its future.
>
> The fundamental feature of all engineering hypotheses is that they state, implicitly if not explicitly, that a *designed* structure will not fail if it is used as intended. Engineering failures may then be viewed as disproved hypotheses. . . . [T]he past success of an engineering structure confirms the hypothesis of its function only to the same extent that the historical rising of the sun each morning has reassured us of a predictable future.

H. Petroski, TO ENGINEER IS HUMAN. THE ROLE OF FAILURE IN SUCCESSFUL DESIGN (New York, 1985) at 44-45. *See also* C. L. Carver, D.C. Schroder and A. J. Tarquin, INTRODUCTION TO ENGINEERING 16 (1987); S. C. Florman, THE INTROSPECTIVE ENGINEER 120-121 (1996).

Amici submit that there is no basis for different treatment of studies of accident causation and modes of component failure and other science evidence. While as this Court recognized that important differences exist between truthseeking in the courtroom and in the laboratory:

> scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly. The scientific project is advanced by broad and wide-ranging consideration of a multitude of hypotheses, for those that are incorrect will eventually be shown to be so, and that in itself is an advance. Conjectures that are probably wrong are of little use, however, in the project of reaching a quick, final and binding legal judgment--often of great consequence--about a particular set of events in the past. We recognize that, in practice, a gatekeeping role for the judge,

> no matter how flexible, inevitably on occasion will prevent the jury from learning of authentic insights and innovations.

Daubert, 509 U.S. at 597, 113 S. Ct. at 2798-99.

The "scientific method" is not peculiar to "pure" science, or to "applied" science or to disciplines which may be called "science." It is a mode of thinking and comparing theory [hypothesis] with reality [experimentation and observation] that pervades modern thought, and is an integral part of fact finding. It is, in short, a means for separating the objective from the subjective.

Daubert instructs us that the district court must determine admissibility under Rule 702 by following the directions provided in Rule 104 (a).

We believe that the district court in this case properly exercised is gatekeeping function and correctly excluded the testimony of the plaintiffs' expert, because that testimony was entirely subjective, not based on any accepted scientific or technical methodology, and thus unverifiable. In sum, it was not reliable. Because it came from the mouth of a professional engineer, the potential for misleading the jury was great.

CONCLUSION

Daubert and its progeny give the district court discretion to "keep the gate" for the purpose of admitting or excluding opinion testimony. The district court did not abuse that discretion in concluding that the causation evidence proffered by Mr. Carlson should be excluded. It was within the trial judge's discretion to conclude that Mr. Carlson's testimony was not based on appropriate scientific principles and methods as required by *Daubert* and its progeny, and, therefore, was not sufficiently reliable for the jury to consider.

Amici respectfully submit that this Court should reverse the decision of the three-judge panel and affirm the judgment of the district court.

Dated: August, 1998

Respectfully submitted,

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ADDENDUM

TESTING OF TIRES

The combination of road, tire, vehicle, and driver forms one system. The mechanical characteristics of the tire in contact with the road must combine with the mechanics of the vehicle to produce driver-friendly operational features for the tire-vehicle system. With reference to the role of a tire, it is necessary to distinguish between symmetric and anti-symmetric modes of performance:

1. the tire supports the vertical axle load and transmits longitudinal braking or driving forces;
2. the tire supplies the cornering and chamber forces necessary for the directional control of the vehicle.

The usual components of a tire are listed in Table 1.

The tests for tires fall into two categories:

1. Mechanical characteristics of the tire such as:

    - load deflection of a vertically loaded mounted tire, load-carrying capacity, and load rating;
    - steering properties as aligning torque, cornering characteristics, tire lateral and tangential stiffness;
    - traction and wet skid performance;
    - rolling resistance;
    - noise;

2. Durability characteristics such as:

    - tread wear, which encompasses slow wear rates, fast wear rates, and uniformity of wear;
    - casing fatigue resistance;

    - heat buildup under loaded dynamic conditions;
    - chipping, cutting, and tearing resistance of the tread and sidewall.

Laboratory testing of tires requires as a preliminary step the testing of the compounds. For compounds such as tread, sidewall, wire coat compound, and liner, the tests include determination of the kinetics of vulcanization, tensile strength, resilience, and dynamic properties. Reinforcements such as the ply cords are tested for tensile strength, creep behavior, stability, and fatigue resistance. A list of the ASTM tests is presented in Table 5. Much of the testing is performed by robotics.

Testing of tires depends on the application for which the tires were designed. The usual properties of interest are listed in Tables 2 - 4. The laboratory equipment designed to test these tire properties are based mostly on a steel flywheel with the appropriate monitoring devices such as transducers and infrared temperature monitors. Data are collected directly into computers for real-time analysis and downloading to the tire engineer's work station. Many of these flywheels are also computer controlled so as to simulate service conditions. For example, aircraft tires can undergo a complete cycle of taxi, takeoff, and landing.

Proving ground testing allows all types of tires to be tested under closely monitored conditions such as:

1. High-speed tracks;

2. Interstate highway simulation;

3. Gravel and unimproved roads;

4. Cobblestone;

5. Cutting, chipping, tearing courses;

6. Wet and dry skid pads;

7. Tethered tracks for farm tire durability;

8. Glass roads for footprint monitoring.

Computer-based simulations of tire testing are frequently used before proceeding to the proving grounds. Once a tire meets the requirements of the laboratory and proving grounds tests, commercial evaluation is the following step in the product R&D cycle.

Quality assurance, the last stage in the manufacturing cycle, includes:

1. Buffing and trimming off mold flash from the tire;

2. Visual inspection of each tire for defects;

3. X-ray checks on tires for ply cord spacing and belt layup;

4. Statistical sampling of tires for durability tests, uniformity, and dynamic balancing. This testing includes many of the R&D tests such as conicity, radial runout, and lateral force variation.

TABLE 1. Components of a Tire

Tread:	The wear resistance component of the tire in contact with the road. It must also provide traction, wet skid, and good cornering characteristics with minimum noise generation and low heat buildup. Tread components consist of blends of natural rubber, polybutadiene (PBD), and styrene-butadiene rubber (SBR), compounded with carbon black, oils, and vulcanizing chemicals.
Tread shoulder:	The upper portion of the sidewall; it affects tread heat dissipation and tire cornering properties.
Tread base:	The rubber compound used to ensure good adhesion between belts and tread, heat dissipation, and low rolling resistance.
Sidewall:	It protects the casing from side scuffing, controls vehicle/tire characteristics, and assists in tread support. Its compounds are natural rubber, SBR, PBD, carbon black and oils.
Curb guard:	The protrusion of rubber sidewall running circumferentially around the tire to protect it from scuffing on curbs.
Beads:	The non-extensible steel wire loops which anchor the plies and also lock the tire onto the wheel assembly so that it will not slip or rock on the rim.
Bead area:	Its components include; 1) the apex or

bead filler; 2) the chafer, which protects the wire bead components; 3) the chipper, which protects the lower sidewall; and 4) the flipper, which helps hold the bead in place.

Plies: The textile or steel cords extending from bead to bead and serving as the primary reinforcing material in the tire casing.

Belts: The layers of textile or steel wire lying under the tread and serving to stiffen the casing.

Shoulder belt wedge: The high-adhesive rubber compound in the shoulder region between the belts and casing; it improves tread wear and durability.

Liner: The butyl rubber and derivatives of such polymers which retain the compressed air inside the tire.

TABLE 2. Tire Properties

Cornering coefficient:	the lateral force divided by the vertical load at a 1° slip angle
Conicity:	tendency of a tire to pull to one side because of off-center tire components such as the belt package
Balance:	distribution of weight around a tire or wheel assembly. The uniform distribution of weight around a tire will give a balanced tire.
Force variation:	Periodic variation of the normal vertical force of a loaded free-rolling tire which repeats each revolution.
Lateral force:	A tire force in the lateral plane developed primarily during cornering.
Lateral force coefficient:	The lateral force divided by the vertical load.
Runout:	The difference between maximum and minimum indicator readings as applied to radial and lateral runout.

Radial runout: The difference between the maximum and minimum measurements on the tread surface and in a plane perpendicular to the spin axis while the tire is mounted on a true wheel.

Lateral runout: The difference between the maximum and minimum measurements parallel to the spin axis at the widest point of each tire sidewall on a true wheel.

Rolling resistance: The resistance of a tire to free rolling.

Self-aligning torque: The stabilizing reaction to slip angle which helps the tire and vehicle to return to neutral conditions at the completion of a maneuver.

Slip angle: The angle between the vehicle's direction of travel and the direction in which the front wheels are pointing.

Uniformity: A measure of the tire's ability to run smoothly and vibration free; sometimes measured as tire balance or radial and lateral force variation.

Speed rating: Ratings are identified by letters. (see Table 3).

TABLE 3. Speed Ratings

Symbol	Maximum speed	Typical application
Z	>162	Super high-performance
W	162	High-performance spots cars
V	149	High-performance cars
H	130	Performance luxury cars
T	118	Passenger cars
S	112	Passenger cars, light trucks
M	81	Trucks
L	75	Trucks

TABLE 4. Desirable Properties of Tire Components

	Tread	Sidewall	Plies	Liner
Maximum:				
	Traction	Adhesion	Cord Adhesion	Plies Adhesion
		Thermal Oxidative Stability		Thermal Oxidative Stability
		Cleanability		
Minimum:				
	Rolling	Weather	Heat Buildup	Air Permeability
	Wear	Flex Cracking	Flex Cracking	
	Cut Growth	Heat Buildup	Heat Buildup	
	Groove Cracking	Curb Scuffing		

TABLE 5. ASTM Tests of Tire Compounds

ASTM test	Compound
D 412 - Tension	Tread
D 413 - Adhesion to flexible substrate	Ply coat
D 429 - Adhesion to rigid substrate	Wire coat
D 430 - Dynamic fatigue	Sidewall, wire coat, ply coat, liner
D 518 - Surface cracking	Sidewall
D 572 - Deterioration by heat and oxygen	Sidewall
D 623 - Heat generation and flexing fatigue in compression	All
D 624 - Tear resistance	Tread
D 1054 - Resilience by rebound pendulum	Tread, wire coat, ply coat
D 1149 - Surface ozone cracking	Sidewall
D 1415 - International hardness	All
D 1434 - Gas permeability coefficient	Liner
D 1630 - Abrasion resistance	Sidewall
D 1646 - Viscosity and vulcanization	All
D 2084 - Oscillating disk cure meter	All
D 2137 - Brittleness point of flexible polymers	Ply coat, liner
D 2138 - Adhesion to textile cord	Ply coat
D 2228 - Abrasion resistance	Tread
D 2229 - Adhesion to steel cord	Wire coat
D 2231 - Forced vibration	Tread, wire coat, ply coat
D 2240 - Durometer hardness	All
D 3395 - Dynamic ozone cracking	Sidewall
D 3985 - Oxygen gas transmission rate	Liner